Extra-long Hole Spin Relaxation Time in InGaAs/GaAs Quantum Wells Probed By Cyclotron Resonance Spectroscopy

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Strained InGaAs/GaAs heterostructures exhibit continuously growing attention, stimulated by the demonstration of efficient spin injection, circular-polarized electroluminescence in InGaAs/GaAs Schottky diodes, as well as the discovery of the anomalous Hall effect in Mn δ-doped InGaAs/GaAs quantum wells [1-3]. For spintronic applications a particularly crucial parameter is the carrier spin relaxation time, which desirably should be as long as possible. In the present work, we show the existence of an extralong, ms range, spin relaxation time of holes in strained InGaAs/GaAs quantum wells, using high-field cyclotron resonance (CR) spectroscopy.

The sample we have studied consists of fifty 7 nm wide $In_{0.14}Ga_{0.86}As$ quantum wells separated by 50 nm wide barriers, δ-doped with carbon. More detailed information about the sample can be found in our previous studies [4-5]. In our experiments, we have used two types of magnetic field coils: one delivers around 50 T with 12 ms rise-time (~100 ms total pulse duration), and another is able to produce 70 T with 35 ms rise-time (~150 ms total pulse duration). The details of our cyclotron resonance setup are given in Ref. 6. We found a strong hysteresis in the spectral weights of cyclotron resonance absorption when a rapidly changing magnetic field is used for the experiment (first magnetic-field coil type), while the hysteresis vanishes when a much slower changing magnetic field is used (second magnetic-field coil type). We argue that this behavior is caused by a long energy relaxation time between two lowest spin-split hole Landau levels, which is comparable with the magnetic field rise-time (~10ms). This implies a long hole spin relaxation time.

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